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Comprehension and interpretation (sciences) 1972

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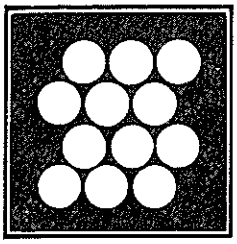
examination

afternoon session:
wednesday
19 july
1972

time allowed:
two hours



comprehension & interpretation (science)

instructions to candidates

This is a test of your ability to read and understand material of a scientific nature. It is possible to do well on this test even if you have studied only a little science at school. The test consists of 11 units (63 questions in all) to be answered in two hours.

You will obtain the best possible score if you observe the following points: (1) Work carefully through the questions in the order in which they are given. (2) Don't waste too much time on any one question; if necessary, go on to the next question and come back to the difficult ones later. (3) If you think you know an answer, mark it—even if you are not certain you are correct. Marks will **not** be deducted for wrong answers. (4) Make sure that you mark the letter you have chosen in the correct line on your answer sheet.

answering

Each question has four alternative answers, represented by the letters A B C D. You must choose one answer from these alternatives. Having done so, make sure you mark your answer correctly.

If you want to change an answer, erase your first mark completely. Try to avoid having to make erasures by not answering hastily. Take care that your pencil mark does **not cross** into another row or column, and that there are no marks or smudges on your answer sheet.

Now look through this booklet, but **don't start writing** until the supervisor tells you to do so.

THE ASPIRIN AGE

ONE OF THE GREATEST CURIOSITIES IN MODERN MEDICINE IS THAT THE MOST WIDELY USED DRUG IN HISTORY HAS DEFIED ALL EFFORTS TO EXPLAIN HOW IT WORKS.

529-1

THIS IS ASPIRIN, WHICH IN BRITAIN ALONE IS CONSUMED AT THE RATE OF 4,000,000,000 TABLETS PER YEAR.

ASPIRIN HAS THREE MAIN BENEFICIAL EFFECTS: IT LOWERS FEVER TEMPERATURES, REDUCES INFLAMMATION IN JOINTS, AND KILLS PAIN—BUT PRECISELY HOW IT DOES THIS REMAINS A MYSTERY.

NOW, RESEARCH AT THE ROYAL COLLEGE OF SURGEONS IN LONDON HAS LINKED ASPIRIN WITH A POWERFUL BUT LITTLE UNDERSTOOD GROUP OF COMPOUNDS IN THE BODY: THE PROSTAGLANDINS...

THE HISTORY OF MANKIND'S MOST POPULAR DRUG DATES FROM 1763, WHEN THE REV. EDWARD STONE ADDRESSED THE ROYAL SOCIETY IN LONDON.

HE REPORTED SUCCESS IN REDUCING THE FEVERS OF "AGUE" (MALARIA) WITH EXTRACTS FROM WILLOW BARK (LATER ISOLATED AS SALICYLIC ACID).

529-2

SALICYLIC ACID, HOWEVER, HAD IRRITANT SIDE EFFECTS, AND THE REAL BREAKTHROUGH ONLY CAME WHEN A GERMAN CHEMIST, FELIX HOFMANN, SYNTHESISED ACETYLSALICYLIC ACID, OR ASPIRIN.

GERMAN DOCTORS WERE THE FIRST TO USE IT MEDICALLY, AGAINST RHEUMATIC FEVER, AND IN 1900 NOTED ITS UNEXPECTED POTENCY IN THE RELIEF OF PAIN.

THROUGHOUT THIS CENTURY ASPIRIN IN VARIOUS FORMS HAS BECOME ENORMOUSLY POPULAR, WHILE PHARMACOLOGISTS HAVE TRIED IN VAIN TO DISCOVER HOW IT WORKS.

RECENTLY, HOWEVER, A TEAM AT THE ROYAL COLLEGE OF SURGEONS, LED BY PROF. JOHN VANE, HAS MADE SIGNIFICANT PROGRESS.

IN 1960 VANE WAS STUDYING THE SUBSTANCES (SUCH AS HISTAMINE) RELEASED IN THE BODY WHEN INFLAMMATION OCCURS.

529-3

HE FOUND THAT A GROUP OF NEWLY DISCOVERED COMPOUNDS, CALLED PROSTAGLANDINS, WERE INVOLVED—AND ALSO THAT ASPIRIN INHIBITED THEIR PRODUCTION...

THE DISCOVERY THAT ASPIRIN INHIBITED THE BODY'S PRODUCTION OF PROSTAGLANDINS BECAME IMPORTANT WHEN THESE COMPOUNDS WERE SHOWN TO CAUSE INFLAMMATION.

ASPIRIN'S ANTI-INFLAMMATION EFFECTS MIGHT, THEREFORE, BE ACHIEVED SIMPLY BY BLOCKING THE CAUSATIVE AGENT FROM THE SITE.

529-4

SINCE PROSTAGLANDINS ARE NOW ALSO BELIEVED TO PROVOKE FEVER, ASPIRIN'S DRAMATIC ABILITIES IN THIS FIELD ARE NO LONGER SURPRISING.

IF CURRENT RESEARCH IMPLICATES PROSTAGLANDINS IN PAIN ITSELF, ASPIRIN'S THIRD AND MOST MYSTERIOUS POWER WILL BE EXPLAINED...

PROFESSOR VANE'S WORK WITH ASPIRIN AND PROSTAGLANDINS MAY OPEN SIGNIFICANT PATHWAYS IN WIDER FIELDS OF MEDICINE.

PROSTAGLANDINS ARE KNOWN, FOR EXAMPLE, TO HAVE IMPORTANT ROLES IN BOTH MALE AND FEMALE REPRODUCTIVE FUNCTIONS.

THE POWER TO CHECK THE BODY'S SYNTHESIS OF THESE COMPOUNDS WITH ASPIRIN COULD BECOME A KEY FACTOR IN BIRTH CONTROL METHODS.

MORE IMPORTANTLY, AN UNDERSTANDING OF HOW ASPIRIN ITSELF WORKS WILL ALLOW BETTER ASPIRIN-LIKE DRUGS TO BE MADE...

529-5

UNIT 1

The drawings and information presented under the title ' The Aspirin Age ' are to be used in answering Questions 1–6.

1 Which of the following is **not** given as an effect of aspirin?

A inhibition of prostaglandin production
B reduction of inflammation
C lowering of body temperature
D curing of common colds

2 Aspirin was first observed to be a pain reliever

A by the Rev. Edward Stone in 1763.
B by German doctors in 1900.
C by Professor Vane during his work on histamine.
D when it was related to male and female reproductive functions.

3 Research has **not** yet shown that prostaglandins are involved in

A inflammation.
B reproduction.
C fever.
D pain.

4 Of the following, which have been shown to be involved in inflammation reactions of the body?

A histamine only
B prostaglandins only
C both histamine and prostaglandins
D acetylsalicylic acid only

5 To date, research in this area has revealed that

A what prostaglandins cause, aspirin can cure.
B aspirin plays a key role in birth control methods.
C prostaglandins can be synthesized from acetylsalicylic acid.
D aspirin may relieve inflammation by preventing certain substances reaching the site of injury.

6 Which of the following best describes the present status of aspirin in the eyes of the scientists?

A Pharmacologists have tried in vain to discover how it works.
B An understanding of the way aspirin works has resulted in the production of new aspirin-like drugs.
C Current research has led to a partial understanding of how aspirin works.
D In taking 4,000 million tablets per year, Britons have provided an excellent experimental population for verifying aspirin's safe and sure effects.

UNIT 2

Three general requirements for protective design in cars have been advocated. To increase the protection of its passengers, the car should have :

1 *a sound outer shell* whose structure withstands impact, absorbs shock, and yet is strong enough so that the object hit by the car does not penetrate the passenger compartment ;
2 *interior surfaces free from hard, sharp projections or edges.* Parts which must project (such as the steering column) should be shock-absorbing and unable to penetrate further into the passenger compartment ;
3 *passenger restraint systems*, not necessarily limited to seat belts, to minimize movement of the body during collision and prevent sudden contact with the interior of the car.

The figures below show information obtained from a survey of a large number of accident cases resulting from car collisions. A ' cause of injury ' is whatever is immediately responsible for injury when a car is stopped and the passengers ' keep going '. Following impact there is therefore a **second collision**, involving the car's occupants with the inside of the vehicle, and it is this second collision that causes most of the injuries and deaths.

Figure 1 shows the **number of injuries** in the survey for each of the leading causes of injury.

Figure 2 shows the **weighted injury score**. Certain ' causes ' tend to result in more severe injuries than others. Each injury was weighted according to its severity by a panel of doctors involved in the survey.

Seat belts were not fitted in any of the vehicles surveyed.

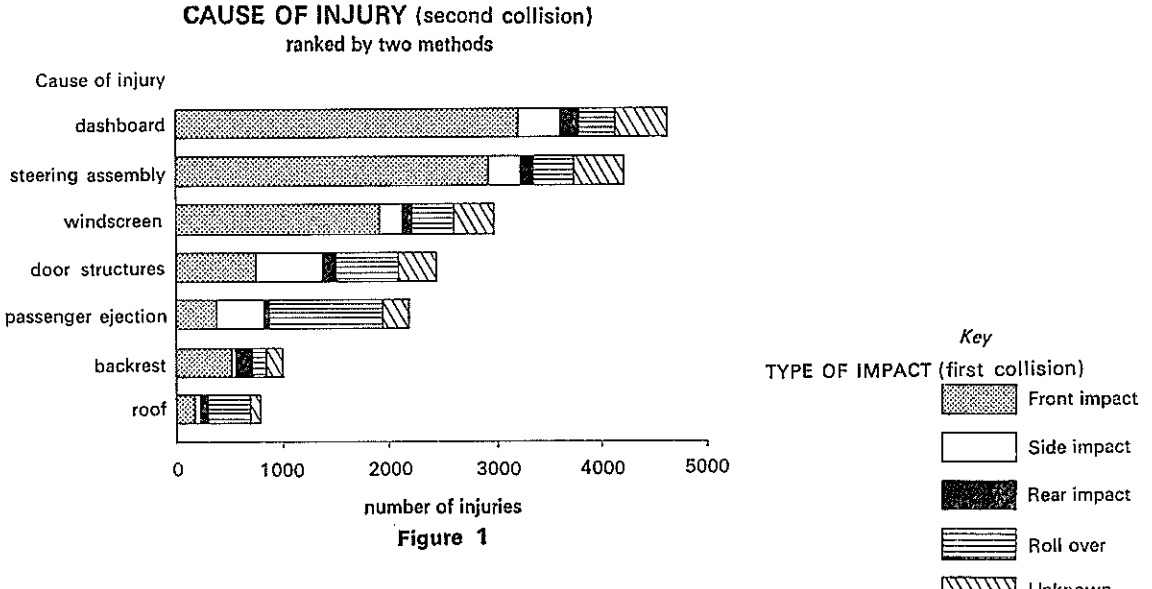


Figure 1

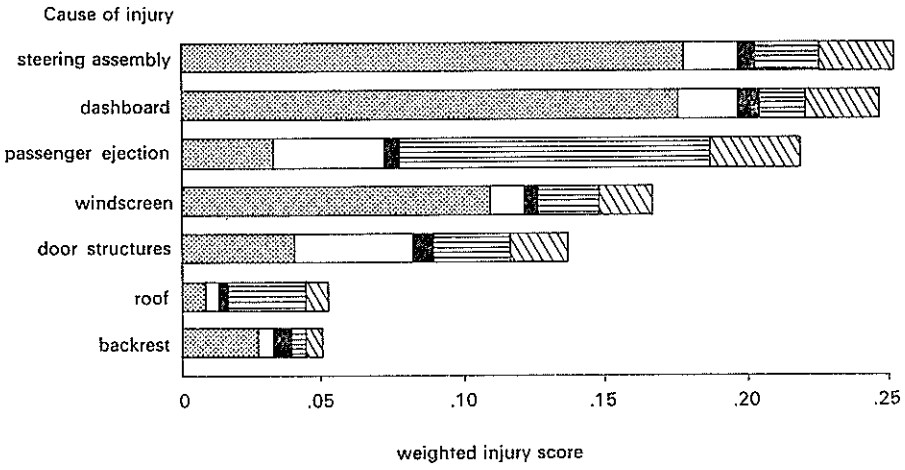


Figure 2

7 Passenger injuries in a car accident generally result from

A the inability of the outer shell of the car to withstand impact and absorb shock.
B penetration of the passenger compartment by objects struck by the car.
C the ejection of passengers following impact and roll over.
D the impact of the passengers with the inside of the car.

8 Injuries from door structures occur more often than, but are generally less severe than, those from

A the dashboard.
B the passengers being ejected.
C the steering assembly.
D the roof.

9 If a passenger is injured as a result of one of the ' causes ' in a car accident, the probability that the ' cause ' was ejection of the passenger from a car is approximately

A $\frac{1}{8}$
B $\frac{1}{4}$
C $\frac{1}{2}$
D $\frac{9}{10}$

10 If the dashboard is the cause of injury, then it is more likely that the car

A was struck so that it rolled over, than struck from the front.
B was struck so that it rolled over, than struck from the rear.
C was struck from the side, than struck from the front.
D was struck from the rear, than struck from the side.

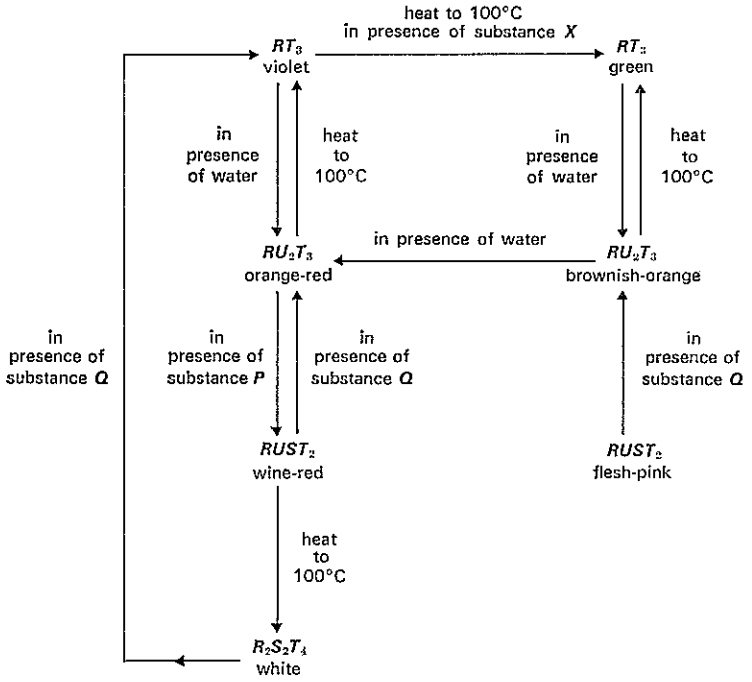
11 Car designers use the results of investigations into accidents to try to remove hazards and so design safer cars. On the basis of the evidence presented, which one of the following design proposals should be most urgently considered to reduce hazards in car accidents?

A The steering assembly is made so that it collapses under impact by the driver.
B The passengers are restrained so that they cannot be ejected from a car during a collision.
C The windscreen is made from shock-absorbing shatterproof material.
D The shell of the car is designed to resist penetration by objects struck.

UNIT 3

A variety of chemicals can be made with a limited number of elements, R, S, T, and U. For example, the chemical represented by RU_2T_3 contains only particles consisting of one atom of R, two atoms of U, and three atoms of T. Many chemicals consisting of R, S, T, and U are coloured. Sometimes two chemicals may have the same number of atoms of R, S, T, or U in each particle, but the atoms are arranged in space in a different way. One result of such a different arrangement may be a difference in colour of the chemicals.

In the diagram below, some of the reactions of chemicals composed of the elements R, S, T, and U are shown. The necessary conditions for each reaction are shown next to the arrow which indicates the direction of the reaction. In answering the questions, two assumptions should be made : firstly, that no reactions other than those indicated occur among the chemicals ; secondly, in any reaction all of the reacting chemicals are used up, except in situations where conditions are such that a particular reaction A ⟶ B and its reverse B ⟶ A are occurring at the same time.



12 A chemist has some green RT_3 and wishes to produce some $R_2S_2T_4$. Which one of the following indicates the conditions, in their correct order, that should be applied ?

A heat to 100°C in presence of substance X ; add water ; add substance P ; heat to 100°C

B add water ; add substance P ; heat to 100°C

C heat to 100°C ; add water ; add substance Q ; heat to 100°C

D add water ; add substance Q ; heat to 100°C

13 Wine-red $RUST_2$ together with some flesh-pink $RUST_2$ is mixed with Q, then water is added to the mixture. When the reactions have been completed, remaining in the vessel would be

A orange-red RU_2T_3.
B brownish-orange RU_2T_3.
C orange-red RU_2T_3 and brownish-orange RU_2T_3.
D wine-red $RUST_2$.

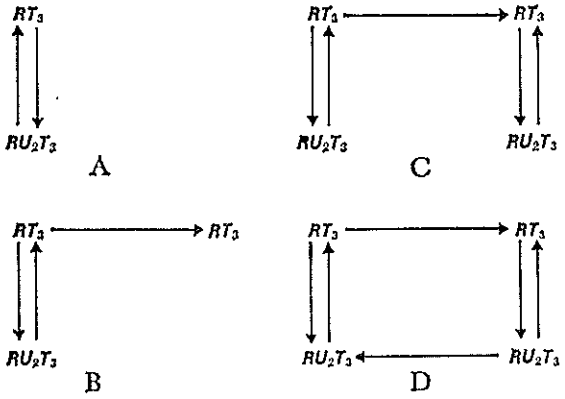
14 A mixture of substance Q and one only of the coloured compounds is allowed to react and then the mixture is heated to 100°C. The same result is obtained if the same coloured compound is first heated to 100°C and then mixed with substance Q.
The colour of the final product is

A green.
B wine-red.
C orange-red.
D violet.

15 Assuming that water at room temperature is added to green RT_3 and all reactions have been completed, what colour is the final product ?

A orange-red
B brownish-orange
C green
D violet

16 Which set of arrows best illustrates the course of the reaction when the orange-red RU_2T_3 is mixed with water and maintained at 100°C in the presence of both substance X and water ?



UNIT 4

The remains of living organisms preserved in rocks are known as fossils. Plant and animal remains which are washed into lakes and seas become covered with sediments which, over great periods of time, are consolidated into beds of sedimentary rocks such as sandstone and mudstone.

Two principles which have been used widely by geologists to determine the relative ages of rocks are :

1 The more recent beds of sedimentary rock formed in a sea or a lake will be closer to the surface unless there have been earth movements such as might upset the arrangement of the beds.

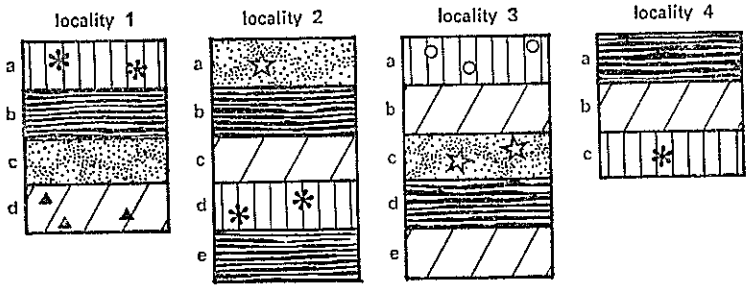
2 There are some fossils that occur only in rocks of a particular geological age but are widely distributed geographically. These are called **index fossils**. The presence of identical **index fossils** in sedimentary rocks in different localities thus indicates that those rocks are of the same age.

Throughout one particular area, it is known that nine successive beds of sedimentary rocks have been laid down on top of one another, and have remained in the same order as that in which they were originally deposited.

However, in some localities within this area more of the surface sediments have been eroded than in other localities.

The following diagrams illustrate sections of the sedimentary beds near the surface in four different localities within the area.

Four index fossils are present and are represented by the symbols, ✻ ▲ ☆ ○



17 In which one of the following are the two beds of sedimentary rocks of the same geological age ?

A 1a and 3a
B 1c and 2a
C 1b and 2b
D 1a and 2d

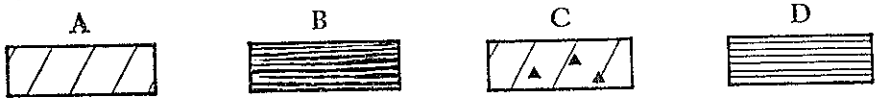
18 The most recent fossil types in the whole area are found in locality

A 1.
B 2.
C 3.
D 4.

19 The oldest index fossil type present in the whole area is

A ✻
B ○
C ☆
D ▲

20 In locality 4, the bed of sedimentary rock immediately below bed c is



21 Assume that in each of the localities 1, 2, 3, and 4 the present surface is represented by the top layer shown. In which locality has the greatest amount of erosion of original sediments occurred ?

A 1
B 2
C 3
D 4

UNIT 5

The information in this unit refers to the effect of temperature on one type of bacteria.

The bacteria can exist as normal cells and also as spores. Spores are more resistant and survive longer than normal cells at the same high temperature. This is illustrated in Figure 1.

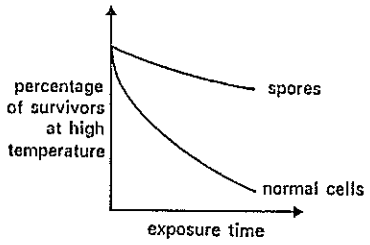


Figure 1

Figure 2 shows the relationships between exposure time and percentage of survivors at three different temperatures, temperature 3 being the highest and temperature 1 the lowest. Instead of plotting the percentage of survivors against time, a graph can be drawn of the **logarithm** of the percentage of survivors against time. This is shown in Figure 3. Different slopes then indicate temperatures of different **efficiencies,** the efficiency being defined as the percentage of bacteria killed in a particular time.

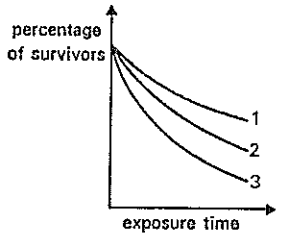


Figure 2

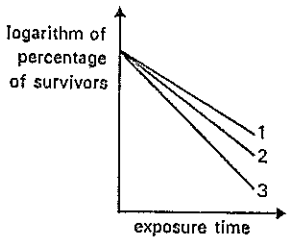


Figure 3

These graphs can be plotted directly on semi-logarithmic graph paper (a special type of graph paper) where one of the axes is scaled in logarithms. Figure 4, plotted on semi-logarithmic graph paper, shows the relationship between percentage of surviving bacterial spores and the time of exposure to five temperatures—*V*, *W*, *X*, *Y*, and *Z*.

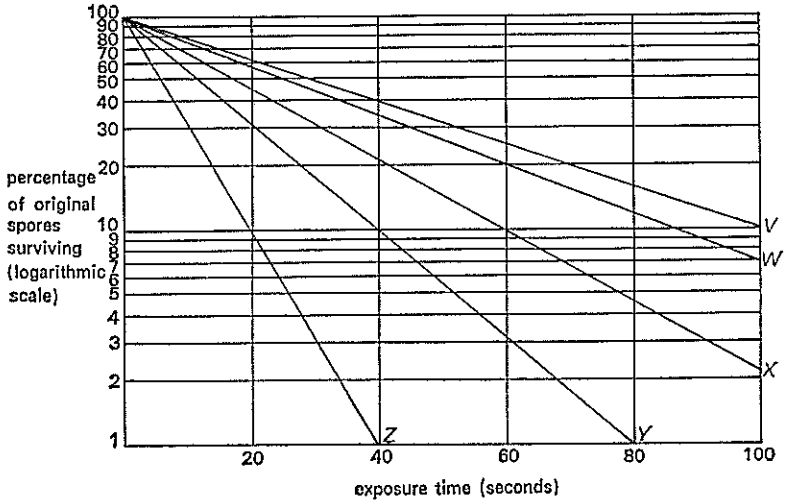


Figure 4

22 A temperature with an efficiency of at least 95 per cent in killing bacterial spores within 30 seconds is required. These conditions could be satisfied by using

A any of *V*, *W*, *X*, *Y*, and *Z*.
B none of *V*, *W*, *X*, *Y*, and *Z*.
C *Z* only.
D *V* only.

23 Consider the effects of temperatures *Y* and *Z* at the beginning of the experiment. As the time of exposure increases up to 40 seconds, the value of

$$\frac{\text{percentage of survivors of } Y}{\text{percentage of survivors of } Z}$$

A remains constant at 2.
B remains constant at 10.
C increases.
D decreases.

24 The time required for temperature *Y* to reduce the number of spores by 80 per cent of the original value is most nearly

A 5 seconds.
B 10 seconds.
C 20 seconds.
D 30 seconds.

25 If *X* represents a temperature of 90°C, which of *V*, *W*, *Y*, or *Z* could correspond to a temperature of 70°C ?

A either *W* or *V*
B either *Y* or *Z*
C *Z* only
D *V* only

26 Compare the efficiencies of temperatures *W* and *X* after the spores have been treated for one minute.
Which one of the following statements is true ?

A *W* is half as efficient as *X*.
B *W* is $\frac{8}{9}$ as efficient as *X*.
C *X* is half as efficient as *W*.
D *X* is $\frac{8}{9}$ as efficient as *W*.

Questions 27 and 28 refer to the following additional information :
Figure 5 shows some graphs of the logarithm of the percentage of bacterial cell and spore survivors for three temperatures (70°, 80°, and 90°C) against time.

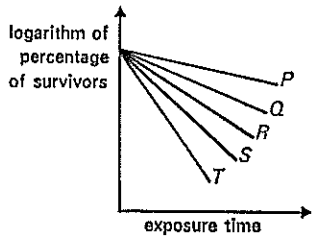


Figure 5

For graph *S* a temperature of 80°C is used on normal bacterial cells. The other graphs represent, though not necessarily in order, the following :

(i) a temperature of 70°C used on normal bacterial cells,
(ii) a temperature of 70°C used on bacterial spores,
(iii) a temperature of 90°C used on normal bacterial cells,
(iv) a temperature of 90°C used on bacterial spores.

27 Which graph corresponds to a temperature of 90°C on normal bacterial cells ?

A graph *Q*
B graph *R*
C graph *T*
D There is not enough information to decide between graphs *Q*, *R*, and *T*.

28 Graph *P* represents

A a temperature of 70°C used on normal bacterial cells.
B a temperature of 70°C used on bacterial spores.
C a temperature of 90°C used on bacterial spores.
D There is not enough information to decide what graph *P* represents.

UNIT 6

In this unit it is assumed that, while fortune tellers may believe in their ' art ', there is at present no scientific basis for this belief.

Fortune tellers have the ability to string together a plausible story by attaching meanings to particular cards as they are laid out from a pack.

The fortune teller who is involved here is an old lady who always follows the rules set out below.

1 She uses a special pack of 24 cards ; the kings, queens, and jacks have only single heads. This is because any one of these 3 cards dealt upside down has a different meaning to one turned up the right way, e.g.

= someone is going to do you a favour

king of clubs right way up

= someone will try to do you a favour but will be prevented

king of clubs upside down

2 The session is started by the client shuffling (mixing) the cards. He is able to see only their backs.

3 The fortune teller then takes the cards and begins dealing from the top of the pack one at a time, turning the cards face up and telling her story.

4 The following is the standard set of responses the old lady uses :

someone will die and leave you their money

you will meet a beautiful girl

someone who will help you

someone will die but you will not benefit

you will meet a beautiful girl who will cause trouble

someone who will try to help you without success

a house or home

a pleasant surprise

reconcillation

someone is going to do you a favour

a girl friend

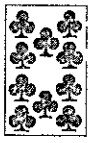
marriage possible

someone will try to do you a favour but will be prevented

a girl friend who is jealous

a marriage is postponed

children



success in business

success in love

 a person to fear

 a gossip

 bad news

 a man who will harm you

 a gossip who will talk about you

 extremely bad news

 a letter

 an unexpected trip

 money you expect will not come to hand

 police

 a gay widow

 an unpleasant boy

 loss of a lawsuit

 a deceiving woman

 an unpleasant boy who means to harm you

 love

 prison

 quarrels

Thus a sequence such as

 (1st card)

 (2nd card)

 (3rd card)

could cause the fortune teller to say

'I can see you taking **an unexpected trip** on which you meet **a beautiful girl** with whom you **quarrel.**'

29 When the fortune teller starts her session by saying, ' I can see a gossip who will talk about you ; she causes quarrels and the police become involved and then a letter arrives, . . . '
how many cards has she turned over ?

A 3
B 4
C 5
D 6

30 The chance that she follows on with ' . . . bringing about a reconciliation ' is

A 1 in 4.
B 1 in 20.
C 1 in 24.
D none of the above.

31 The purpose of the fortune teller getting her client to shuffle the cards is

A to give the client the impression he has been involved in what is to follow.
B to ensure the cards are distributed randomly.
C to reduce the chance of producing sequences that are difficult or embarrassing to explain.
D to ensure fair play on the part of the fortune teller.

32 When the fortune teller begins the following story :
' You will meet an unpleasant boy who tells you some extremely bad news involving a girl friend who is jealous . . . '
the cards in sequence would be

A

B

C

D

33 Given that the next card in the pack is the king of hearts, what is the chance that the fortune teller will read it as, ' Someone will die and leave you their money ', when she turns it over ?

A 50 : 50
B 1 chance in 24
C a certainty
D zero chance

UNIT 7

The advance of scientific knowledge is based on experimentation. Observations are used by scientists as the basis for making hypotheses. A hypothesis is a supposition which is put forward to explain certain observations. Any hypothesis put forward should be consistent with all available observations. In order to test a hypothesis, it must be used to predict observations (results) in new experiments.

If the observations in any new experiment are **not consistent** with the results predicted using the hypothesis, then the hypothesis is rejected.

If the observations of a new experiment are **consistent** with the results predicted by using the hypothesis, this does not prove the hypothesis to be correct, as it is possible that some other new experiment may prove the hypothesis to be inadequate ; rather this lends support to the hypothesis.

Any supposition which cannot be tested by this method of predicting observations in new experiments is **not** a scientific hypothesis.

Today a great deal of scientific work is carried out in circumstances where there is only a limited number of ' possible ' hypotheses to explain a particular observation. In cases such as these, when one of the competing hypotheses is rejected, the original hypothesis is said to be supported. You are to assume that this is true of the hypothesis described in the passage below.

Under natural conditions, the major species which preys upon the freshwater mosquito fish (*Gambusia affinis*) is a larger fish, the pickerel (*Esox americanus*). If *Esox* is introduced into an aquarium containing a school of *Gambusia*, it is observed that *Gambusia* react in a characteristic way, swimming ungrouped at the surface with fins erect.

A biologist studying the relationship between the two species formed the hypothesis :

' *Gambusia* react to one or more chemical substances which pass into the water from the body of *Esox* '.

Among the experiments he performed when investigating this hypothesis was the following :

Experiment 1 : *Esox* was placed into an aquarium for one hour ; then, after removing *Esox* from the water, a group of *Gambusia* was introduced into the aquarium.

34 When Experiment 1 was performed, it was found that when *Gambusia* were placed in the aquarium from which *Esox* had recently been removed, the fish swam ungrouped at the surface with fins erect. This observation

A supports the hypothesis, but does not prove it to be correct.
B proves the hypothesis to be correct.
C proves the hypothesis to be incorrect.
D does not provide data which is relevant to this particular hypothesis.

35 Which of the following best describes the relationship between Experiment 1 and the hypothesis ?

A The experiment is designed to provide data on which to base a new hypothesis.
B The experiment is designed to check on the accuracy of the original observation on which the hypothesis was based.
C The experiment is designed to test a prediction made from the hypothesis.
D The results of the experiment will either prove or disprove the hypothesis.

After completing Experiment 1 the biologist carried out another experiment.

Experiment 2 : *Esox* was placed into an aquarium for one hour. After removing *Esox*, the water in the aquarium was quickly filtered through activated charcoal (which is known to be capable of absorbing many chemical substances). *Gambusia* were then introduced into the aquarium.

36 If *Gambusia* in Experiment 2 behaved normally (i.e. did not swim ungrouped at the surface with fins erect), this observation would

A provide additional support for the hypothesis, but not prove it to be correct.
B prove conclusively that the hypothesis is correct.
C prove conclusively that the hypothesis is incorrect.
D contradict the results from Experiment 1.

37 If in Experiment 2 the *Gambusia* had been observed to swim ungrouped at the surface with fins erect, this observation would

A provide additional support for the orginal hypothesis but not prove it to be correct.
B prove conclusively that the hypothesis is correct.
C prove conclusively that the hypothesis is incorrect.
D neither support nor disprove the original hypothesis.

Two further experiments were conducted.

Experiment 3 : A wooden model of *Esox* was introduced into an aquarium containing *Gambusia*.

Experiment 4 : *Esox* in one glass aquarium were placed alongside another glass aquarium containing *Gambusia* so that the *Esox* would be seen by the *Gambusia*.

38 If in both Experiment 3 and Experiment 4 the *Gambusia* behaved normally (i.e. did not swim ungrouped at the surface with fins erect), this observation would

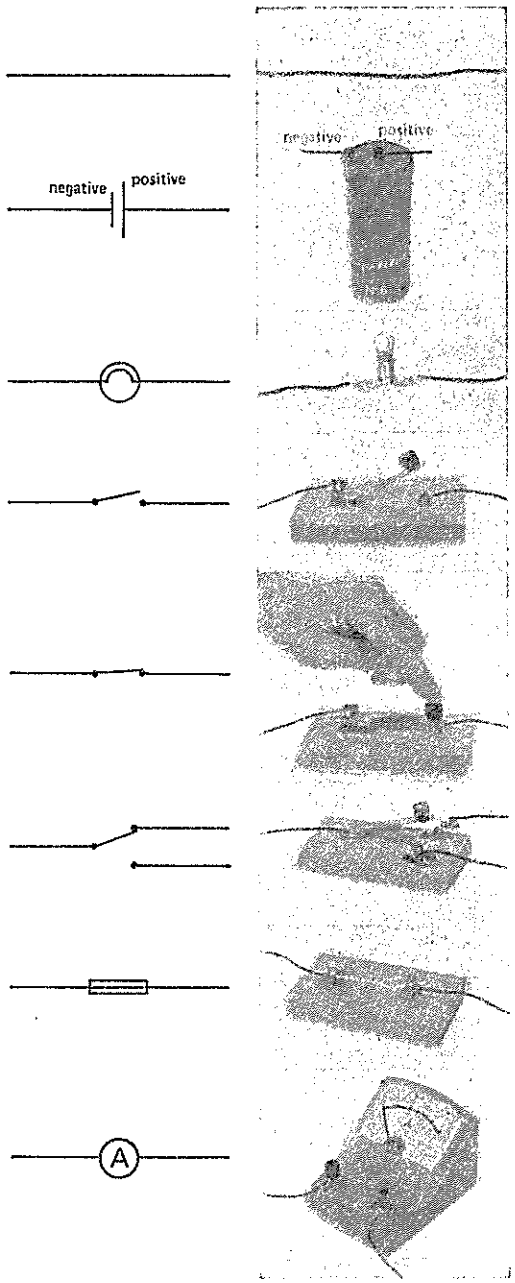
A provide support for the original hypothesis.
B prove that *Gambusia* reacted to the presence of chemicals which pass into the water from the body of *Esox*.
C prove that the original hypothesis is incorrect.
D neither support nor disprove the original hypothesis.

39 If in all four experiments, 1, 2, 3, and 4, the *Gambusia* swam ungrouped at the surface with fins erect, which one of the following statements would be justified ?

A The *Gambusia* react in this characteristic way only if they can see *Esox*.
B The *Gambusia* react in this characteristic way only if chemical substances released by *Esox* are present in the water.
C The *Gambusia* react in this characteristic way only if they can see *Esox* or if chemical substances released by *Esox* are present in the water.
D None of **A**, **B**, or **C** would be justified.

UNIT 8

Questions 40–46 refer to the following information about electric circuits :



connecting wire

cell

globe

switch (open)

switch (closed)

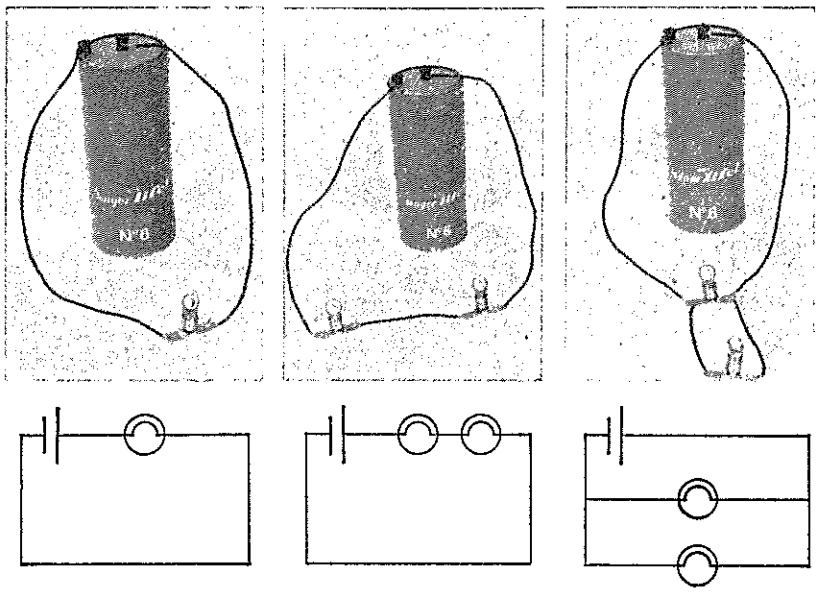
two-way switch

fuse

ammeter (an instrument which measures the electric current)

For electricity to flow continuously, it must have a complete path or circuit through which to travel.

The three photographs and their accompanying diagrams depict **simple electric circuits** operating satisfactorily.



In the following questions, it is assumed that

(*a*) the cells and globes depicted are identical with those in the above diagrams ;

(*b*) the only circuit component which offers resistance to the flow of current is the electric globe.

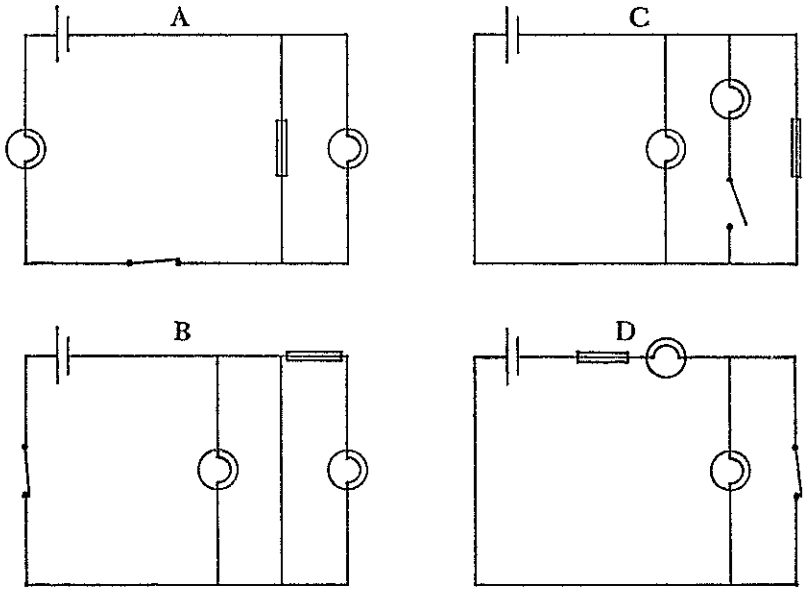
If a connecting wire is joined across the two ends of an electrical component such as a globe, all current flows through the connecting wire. In this situation the connecting wire is said to be a short circuit.

When there are two alternative paths along which current can flow, one containing a resistance (such as a globe) and the other a wire (which is assumed to offer no resistance), all the current will flow through the wire and none through the globe.

Current may be excessive if there is too little resistance; e.g. if a wire is connected directly across the terminals of a battery the current is excessive, but if there is a globe present in the circuit the current is not excessive.

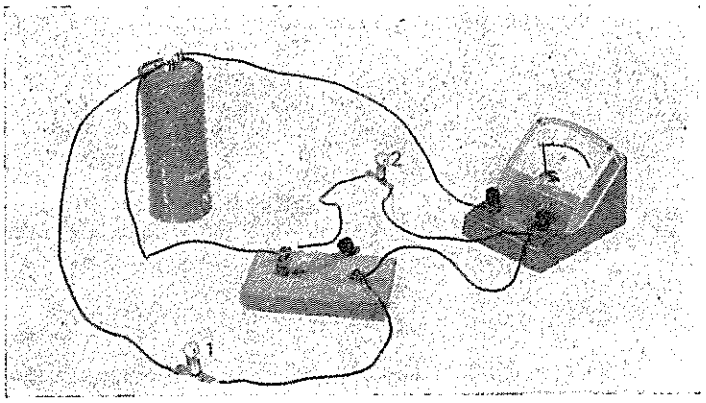
A fuse consists essentially of a piece of wire which becomes hot and melts when the current through it is excessive ; this breaks the circuit.

40 In which one of the circuit diagrams is the fuse wire most likely to melt, thus breaking the circuit ?



41 If in this circuit the switch is open as shown, which of the following is correct ?

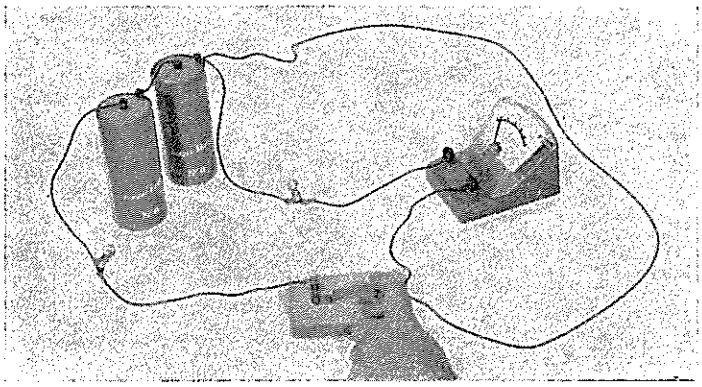
A Globe 1 only will be alight.
B Globe 2 only will be alight.
C Both globe 1 and globe 2 will be alight.
D Neither globe 1 nor globe 2 will be alight.



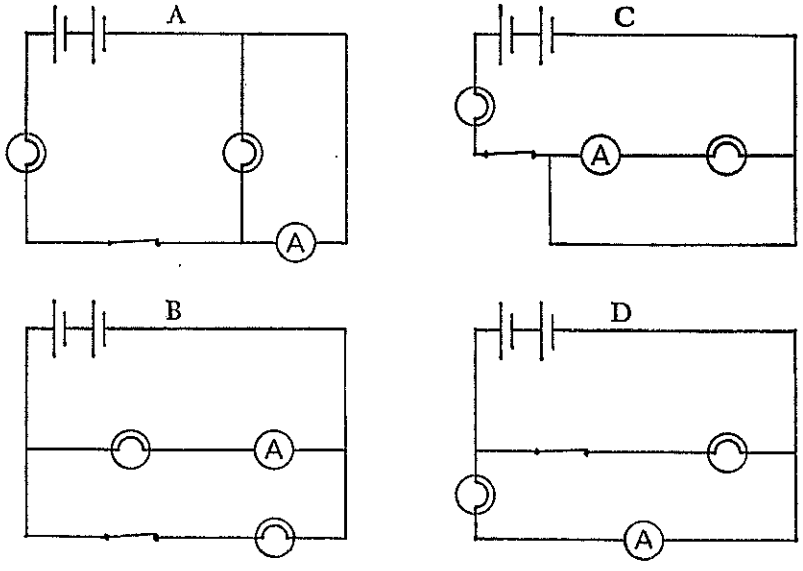
42 If in the circuit shown in question 41 the switch is closed, which of the following is correct ?

A Globe 1 only will be alight.
B Globe 2 only will be alight.
C Both globe 1 and globe 2 will be alight.
D Neither globe 1 nor globe 2 will be alight.

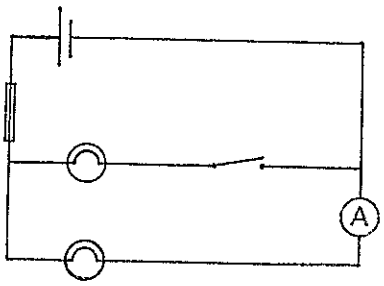
43 Consider the following photograph of an electric circuit.



Which of the circuit diagrams represents this circuit ?

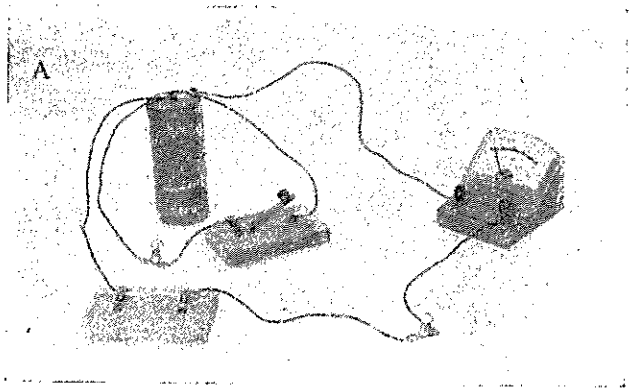


44 Consider the following circuit diagram.

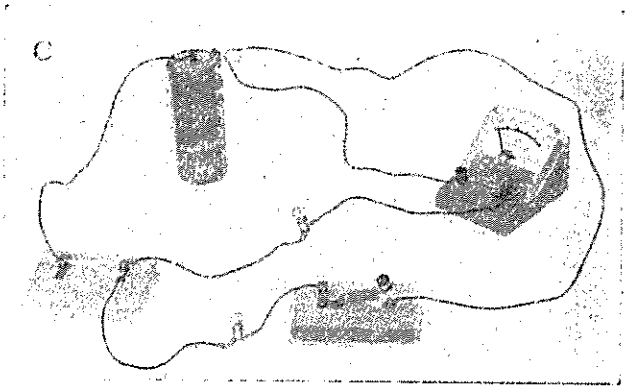


Which of the photographed circuits does the diagram represent ?

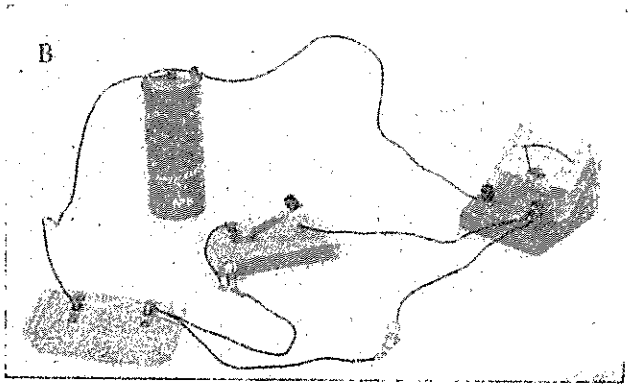
A



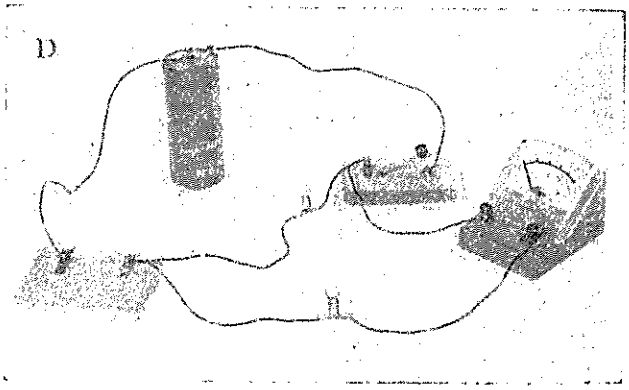
C



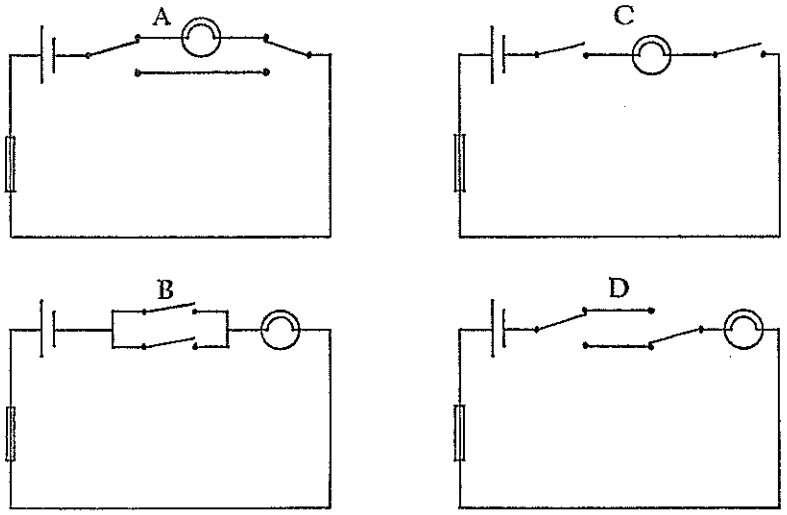
B



D



Questions 45 and 46 refer to the following four circuit diagrams. For each question choose the circuit diagram, **A**, **B**, **C**, or **D**, that would be most appropriate to the situation given.



45 The interior light of a car is required to go on when either or both of the front doors are open.

46 A light in a long hallway is required to be turned on (or off) at one end of the hall and then off (or on) at the other end.

UNIT 9

Gas molecules move randomly at high speeds, colliding with each other and with the walls of their container. If, however, nothing blocks their paths, they go on travelling in the same direction.

As the earth's atmosphere is not bounded above, it might therefore be expected that if a molecule's speed was great enough it would escape into space and never return. The minimum escape speed required to project a molecule permanently into space from the earth is 11.2 kilometre per second. From a given planet, the escape speed is independent of the molecule's mass.

The average speeds of molecules of gases have been calculated. The heavier a gas, the smaller is its molecular speed.

The table below shows how the average molecular speeds of gases in the earth's atmosphere vary with temperature.

	Average molecular speed (km/sec)		
	0°C	100°C	500°C
Hydrogen	1.8	2.1	3.0
Helium	1.3	1.5	2.2
Nitrogen	0.50	0.59	0.84
Oxygen	0.45	0.53	0.76
Carbon dioxide	0.40	0.47	0.67

Although most gas molecules move at speeds close to their average speeds, at any instant some molecules will be moving much faster and others much slower.

The proportion of molecules travelling fast enough to escape from the earth is extremely small—about 1 in 10^{20}.

The rates at which different gases are lost from the earth's atmosphere vary ; the greater the molecular speed, the greater the loss.

For the four ratios listed (questions 47–50), answer

A if the value of the ratio is less than 1 ;
B if the value of the ratio is equal to 1 ;
C if the value of the ratio is greater than 1 ;
D if the value of the ratio cannot be estimated from the information given.

47 $\dfrac{\text{average speed of hydrogen molecules at 0°C}}{\text{average speed of helium molecules at 0°C}}$

48 $\dfrac{\text{fraction of molecules in a sample of hydrogen at 0°C with a velocity greater than 11.2 km/sec}}{\text{fraction of molecules in a sample of carbon dioxide at 0°C with a velocity greater than 11.2 km/sec}}$

49 $\dfrac{\text{mass of a molecule of nitrogen}}{\text{mass of a molecule of oxygen}}$

50 $\dfrac{\text{escape speed of hydrogen at 0°C}}{\text{escape speed of hydrogen at 100°C}}$

UNIT 10

The action of muscles attached to the skeleton is controlled by a type of nerve cell (neurone) called a **motor neurone.** A nerve **impulse** travels from the cell body of the motor neurone and along its long extension or **axon** towards a muscle. When an impulse reaches the end of the axon, the muscle cells contract and shorten.

The motor neurone itself can be affected by two other types of neurone—**excitatory** neurones and **inhibitory** neurones. An impulse in the excitatory neurone causes the end of the axon to release a chemical substance which we will call substance *K*. Substance *K* diffuses from the excitatory neurone to the motor neurone cell body where, as a result, an impulse is initiated. This impulse then travels through the motor neurone towards the muscle. An impulse in the inhibitory neurone causes the release of a chemical substance which we will call substance *M*. When substance *M* diffuses from the inhibitory neurone to the motor neurone, no impulse is initiated in the motor neurone. If both substance *K* and substance *M* reach the motor neurone at the same time, substance *M* cancels the action of substance *K*, and so no nerve impulse is initiated in the motor neurone.

Figure 1 shows three neurones—motor, excitatory, and inhibitory.

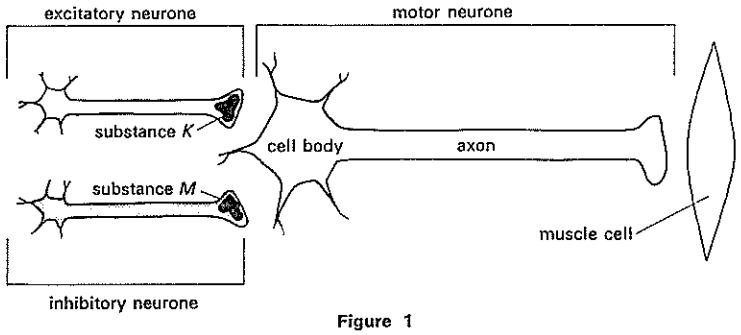


Figure 1

No nerve impulse is occurring in Figure 1. Figure 2 shows the situation when there is an impulse in the inhibitory neurone, and substance *M* has been released and has diffused towards the motor neurone. No impulse has been initiated in the motor neurone.

Note that there is no impulse in the excitatory neurone and so substance *K* has not been released.

When nerve impulses are present they are shown by arrows, and an inhibitory neurone is shown shaded.

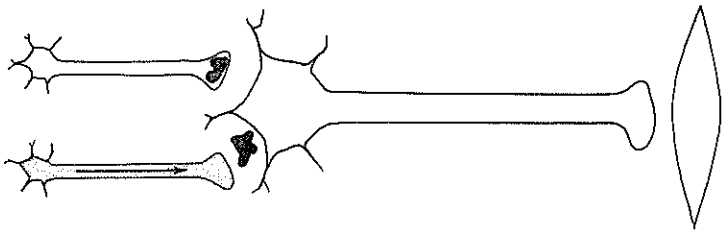
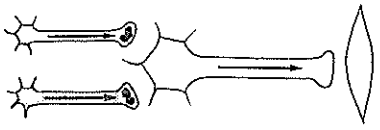


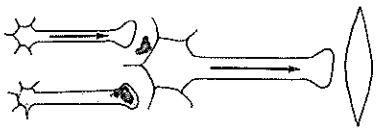
Figure 2

51 Which one of the diagrams below is **consistent** with the data given ?

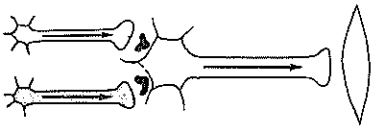
A



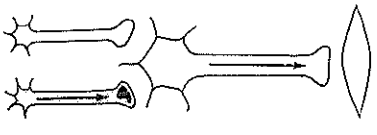
C



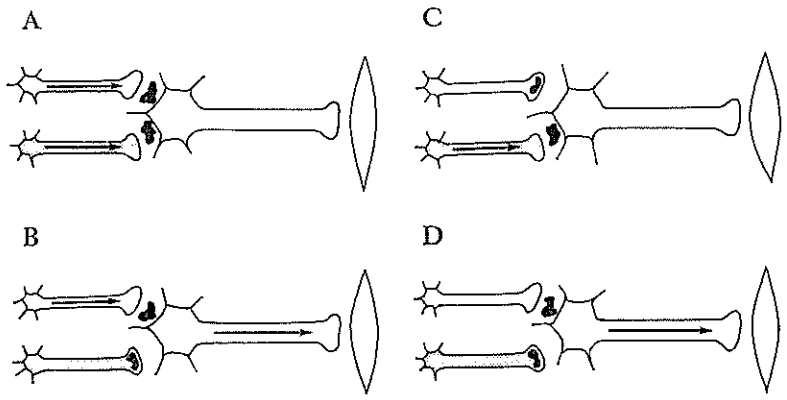
B



D



52 Which one of the diagrams below shows a situation **inconsistent** with the data given ?



In answering questions 53–58 the following additional information may be assumed to be correct. Any neurone may have a single straight axon or a branched one. All nerve impulses travel in one direction only—from the cell body to the end of the axon. An impulse reaches both ends of a branched axon. Figure 3 is a more simplified representation of neurones.

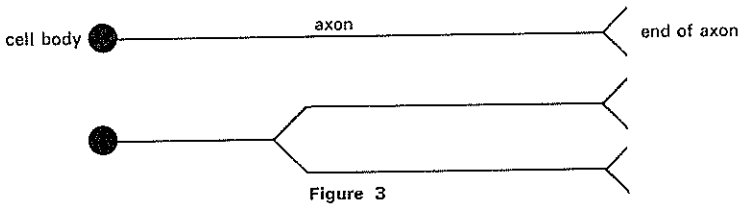


Figure 3

The biceps and triceps muscles, shown in Figure 4, raise and lower the forearm. The figure also shows some of the neurones which control these muscles as the forearm is raised.

When the forearm is raised, the biceps contracts and shortens and the triceps is relaxed and stretched. If impulses stop coming to the biceps, it no longer remains contracted.

In the triceps there is a **stretch receptor.** This structure is activated when the triceps is stretched and it induces an impulse in the cell body *X*.

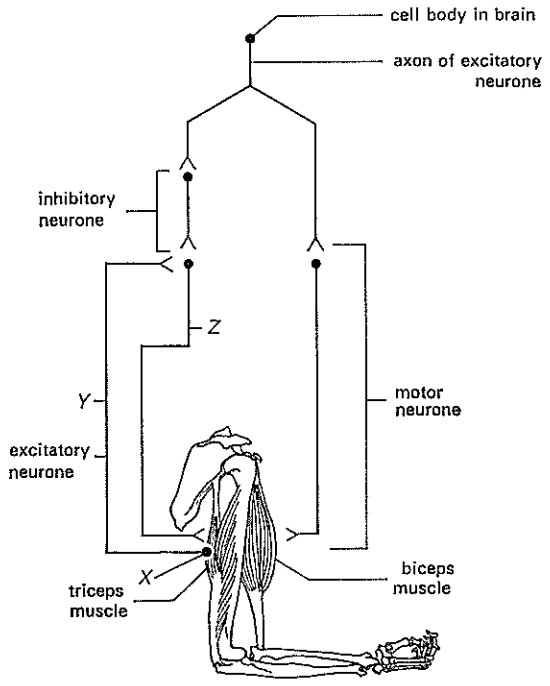


Figure 4

53 The structure labelled *Z* is best described as an axon of

A a motor neurone.
B an excitatory neurone.
C an inhibitory neurone.
D either an excitatory or an inhibitory neurone—it is impossible to tell which.

54 A man wants to raise his forearm. Impulses (which originate in the brain) reach the motor neurone associated with the biceps. The biceps contracts and the triceps is stretched. What happens in the structures *Y* and *Z* ?

A Impulses travel in *Y* but not in *Z* because impulses also reach *Z* from the inhibitory neurone.
B Impulses travel in *Y* and *Z* but do not reach the brain because they are blocked by impulses from the inhibitory neurone.
C Impulses originating in *Z* pass to *Y* (thus by-passing the inhibitory neurone) and activate the stretch receptor near *X*.
D No impulses travel in *Y* or *Z* because impulses from the brain cannot reach the triceps since they are blocked by impulses from the inhibitory neurone.

55 Assuming the biceps has contracted, and the stretch receptor is activated, which of the following statements about impulses is correct ?

A Impulses travel back to the triceps causing it to contract (and thus to oppose the stretching).
B No impulses travel back to the triceps because of the action of the inhibitory neurone.
C Further impulses will be initiated by the brain to keep the stretch receptor activated.
D Impulses travel to the inhibitory neurone which then prevents any impulses from reaching the brain.

56 Suppose a chemical which acts on the nervous system and blocks impulses in motor neurones is introduced into the system. If impulses now come from the brain towards the biceps, the arm will be

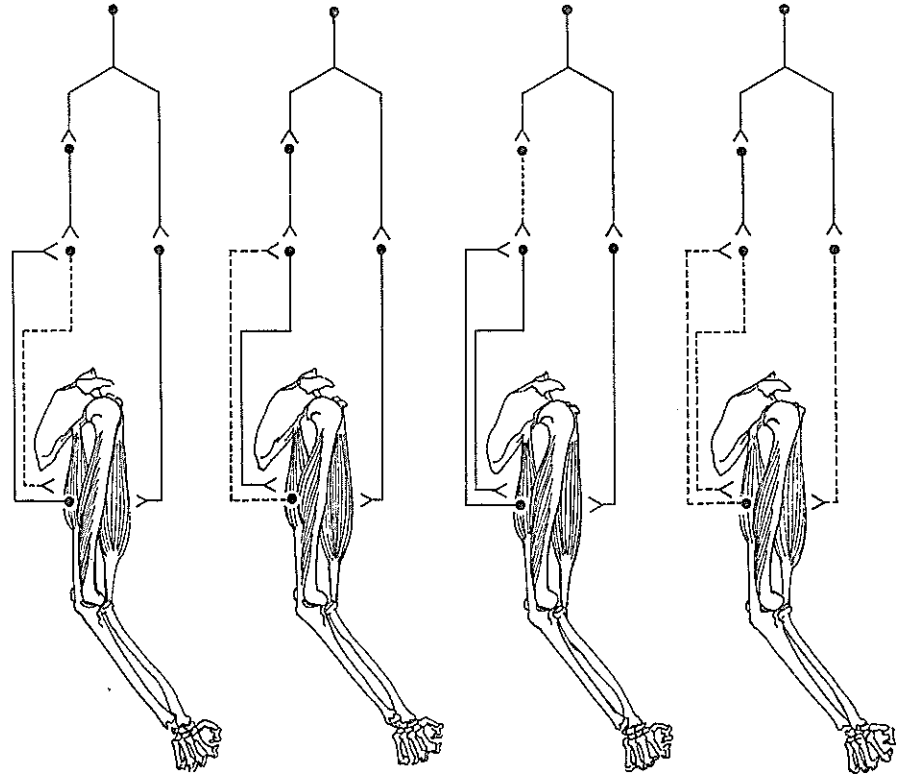
A raised normally as the biceps contracts and the triceps relaxes.
B in a rigid state as both biceps and triceps contract.
C limp as neither biceps nor triceps contract.
D fully extended as the triceps contracts and the biceps relaxes.

57 Suppose a different chemical which acts on the nervous system so that impulses in inhibitory neurones are blocked is now introduced. If impulses now come from the brain to the biceps, the arm will be

A raised normally as the biceps contracts and the triceps relaxes.
B in a rigid state as both biceps and triceps contract.
C limp as neither biceps nor triceps contract.
D fully extended as the triceps contracts and the biceps relaxes.

58 Tetanus is a condition in which the victim is in a state of paralysis and unable to move because the muscles are ' working against each other '.
An impulse originates in the brain of a man suffering from tetanus. Which one of the following diagrams could represent the impulses in his forearm ?
In this question
———— indicates that a nerve impulse is transmitted ;
---------- indicates that no nerve impulse is transmitted.

A B C D

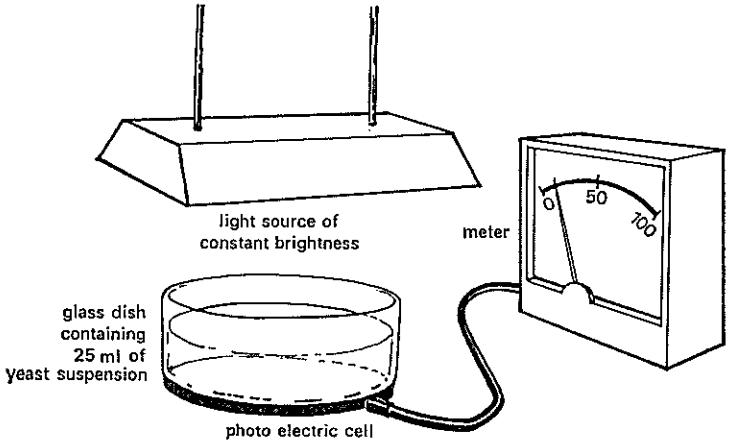


UNIT 11

Yeasts are single-celled organisms which reproduce rapidly in a solution of water and sugar. Yeasts can survive but not reproduce in pure water alone.

Using a photoelectric cell attached to a meter, it is possible to measure the rate at which the yeast cells reproduce under different experimental conditions, such as different temperatures, different kinds of sugar, and different sugar concentrations.

The figure below shows the arrangement of the apparatus.



The determination of this rate involves two procedures.

Procedure 1

Eight separate samples of yeast suspension were prepared containing 1, 2, 3, 4, 5, 6, 7, 8 gram of dry yeast mixed thoroughly with 250 ml of pure water. Standard sized glass dishes containing 25 ml portions of each suspension were taken, and placed, in turn, on the photoelectric cell. Meter readings indicate the amount of light transmitted through the yeast suspensions ; these are given in Table 1.

Table 1

Dry wt of yeast in g/250 ml water	0	1	2	3	4	5	6	7	8
Light meter reading (arbitrary scale) *	93	84	76	69	64	61	58	56	55

*Each entry is the average of 6 separate readings.

Procedure 2

Three glucose solutions were prepared (glucose, a type of sugar, dissolves in water to form a colourless solution).

The *first* contains 18 g of glucose/1000 ml of solution ;

the *second* 36 g/1000 ml ; and

the *third* 54 g/1000 ml.

One litre (i.e. 1000 ml) of each solution is prepared, and 4 g of yeast are added to each litre. A sample of 25 ml of each mixture is then placed in separate glass dishes.

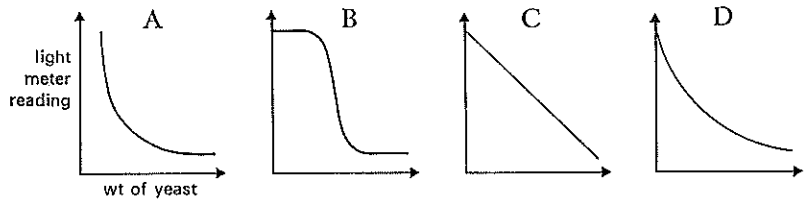
Measurements are made over a period of 12 days, using the same experimental arrangement as in Procedure 1. Some results are shown in Table 2.

Table 2

Time (days)	Meter reading*		
	1st solution	2nd solution	3rd solution
3	81	82	83
6	77	79	74
9	73	71	69
12	72	70	68

*Each entry is the average of 6 separate readings.

59 Which of the following graphs best represents the relationship between the measurements in Procedure 1 ?



60 The best explanation of the results of Procedure 1 is that

A light is necessary to stimulate the growth of yeast.
B as time proceeds, the yeast grows and reproduces.
C in the absence of sugar, the yeast dies.
D increasing the concentration of yeast makes the suspension more opaque to light.

61 The purpose of Procedure 1 in this experiment was most likely to

A provide a basis for estimating the amount of yeast present in suspension in Procedure 2.
B investigate the effect of yeast concentration on the rate of yeast growth.
C investigate the optimum conditions under which yeast would grow.
D investigate the effect of light on the rate of yeast growth.

62 Which one of the following meter readings would be most likely for the first glucose solution in Procedure 2 on day 0 just after mixing in the yeast ?

A 64
B 80
C 84
D 93

63 Of the following 3-day periods in Procedure 2, the fastest growth of yeast occurred between

A days 0 and 3 in the third solution.
B days 3 and 6 in the third solution.
C days 0 and 3 in the second solution.
D days 3 and 6 in the second solution.

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C. H. Rixon, Government Printer, Melbourne.